LAMINATED ROOT ROT

IDAHO DEPARTMENT OF LANDS

State Forester Forum

Introduction

Root diseases are the most damaging type of native forest disease in Idaho north of the Salmon River. They are also the most difficult to manage. Infected trees suffer reduced growth, mortality, and increased susceptibility to bark beetle attack. At the stand-level, root diseases reduce timber volume and stocking, and interfere with short- and long-term forest management objectives. Root diseases are caused by fungi that infect and decay tree roots, causing a loss of both root system function and structure. Loss of root function gradually weakens and kills trees. Loss of root structure results in windthrow of live trees and accelerated collapse of dead ones. The most important root diseases in Idaho are laminated Armillaria, and annosus root rots. Any combination of the fungi that cause these diseases, referred to as "root disease complexes", may be found in the same stand or even on the same tree. Laminated root disease, *Phellinus weirii*, can be found across northern Idaho with Douglas-fir and true firs. The disease is not known to occur south of the Salmon River.

Key Point: *Like Armillaria, variation in host resistance to laminated root disease is not expressed before approximately age 15 to 20. Prior to this age conifer species are considered equally susceptible.*

Conifer Susceptibility to Laminated Root Rot

- Highly susceptible: Douglas-fir and grand fir
- Moderately susceptible: Western red cedar, western hemlock, and subalpine fir
- Least susceptible: Western larch and pines
- Immune: Hardwoods

Biology

Phellinus weirii infrequently produces spores from fruiting bodies on the underside of infected, downed trees and upturned roots. An "individual" of the fungus resulting from successful spore infection is called a clone or "genet". Because relatively few genets exist across a given piece of ground, spore-spread is considered a relatively rare event and not considered important in management of P. weirii.

The main mode of spread of *P. weirii* is tree-to-tree via live root contacts or grafts. When P. weirii infects a root, it grows along the root surface and eventually penetrates the bark to the cambium, initiating decay. The early, or incipient, stages of decay, cause a staining on the stump surface which is readily visible when infected trees are cut (Figure 1).

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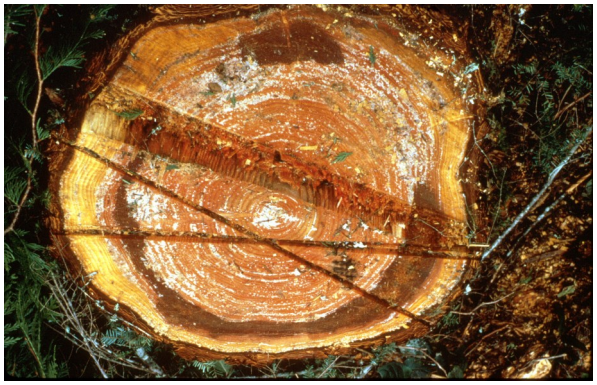

Figure 1. Staining on fresh stump surface due to incipient decay

The fungus kills living tissue of infected trees but is known to survive for over 50-years in large roots and stumps of dead trees. The fungus survives for considerably less time in smaller roots. It is the long-term presence of inoculum, or fungus-infected woody tissue, that makes root disease management difficult when roots of uninfected trees contact the infected roots of a living or dead tree, the fungus grows onto the uninfected root, and the disease is perpetuated. The ability to occupy a site for decades and cause recurrent disease in consecutive forest generations is why root disease is often referred to as a "disease of the site".

As root disease spreads from tree-to-tree it can form roughly circular centers of infection where many of the trees are symptomatic or dead. These areas of concentrated damage are referred to as "root disease centers" (Figure 2).

Figure 2. A Root Disease Center

Laminated root rot spreads outward an average of one foot per year and centers can expand to tens of acres. Numerous root disease centers caused by laminated root rot may be dispersed randomly throughout a stand. Not all diseased areas are delineated by obvious root disease signs. In some instances the disease occurs in a "diffuse" distribution, where individual or small groups of trees are affected across the entire area.

Wildfire will have little effect on laminated root rot because inoculum is protected underground. As fires often change the stand composition to seral species tolerant of root disease, such as western larch and pines, the impact of *P. weirii* is significantly reduced.

Recognizing Root Disease in a Stand

Stand-level "signatures" can aid in identifying the presence of root disease. Root disease centers are the most obvious (Figure 2). Variously-aged snags and trees with symptomatic crowns will be dispersed in and around such centers or diffusely throughout a stand. Death of susceptible species causes gaps in the overstory canopy which promote conifer regeneration, most often of mid- or late-successional disease-susceptible species, or growth of brush. Brushfields can occupy such

sites for decades until conifers regain a foothold. Small hardwood groves, such as aspen, birch, or maple, can be a clue that laminated root rot has had a long-term presence on the site because hardwoods are immune.

Trees infected or killed by root disease lose structural support as large roots decay; when trees uproot these decayed roots break off near the root collar. The root collar, stubs of decayed roots, and attached soil that come from the ground when trees fall are referred to as "root wads" or "root balls" and are very typical of laminated root rot (Figure 3).

Figure 3. "Root Ball" Caused by Laminated Root Rot

Downed trees in root disease centers can be distinguished from windthrown trees by the pattern they form. Windthrown trees that go down in a storm will fall, for the most part, in the same direction. In contrast, trees that fall due to decay caused by laminated root rot will fall at different times and directions, with or without wind.

Bark beetles and root diseases are closely associated. The reduction in tree vigor and changes in tree physiology caused by root disease can make them more attractive to bark beetles. Larger trees experiencing infection over longer periods are more likely to be attacked. When searching for reasons why trees have died, a diagnosis of bark beetles should be followed by an examination for root disease. This may be difficult, however, as beetles often kill trees while evidence of root disease is still subtle.

Identifying Laminated Root Rot

Descriptions and images of root disease-symptomatic trees can be found in "A Field Guide to Diseases & Insect Pests of Northern and Central Rocky Mountain Conifers". Foresters and landowners should always have this guide on hand when diagnosing forest insect and disease problems.

Root diseases cause gradual loss of root function and structure which include:

- reduced terminal and lateral growth over a span of several years;
- crown thinning, often proceeding from the bottom up and inside out;
- off-color or chlorotic (yellowing) foliage;
- slight to heavy resinosus (pitch-streaming) around the base of the tree;
- flushes of small cones, referred to as "stress cones", which can persist after the tree dies; and
- wood decay with unique features characteristic of each root disease.

Figure 4. Typical Root Disease Crown Symptoms (Photo by Susan K. Hagle, USDA Forest Service, www.forestryimages.org)

The size of an infected tree will affect expression of disease symptoms. Larger trees, with more expansive root systems, will develop symptoms more gradually than a sapling or seedling, which may succumb relatively quickly and develop few if any crown symptoms. Large trees may not show symptoms for years after infection until much of their root system is compromised. Therefore, any disease-susceptible tree within 30-feet of an infected tree should be considered infected.

> **Key point:** *A general rule-of-thumb is only about half of all root disease-infected trees can be detected by above-ground symptoms at any one time.*

Signs of the fungus itself may be found on the exterior of roots of live, symptomatic trees. This superficial fungal growth of P. weirii is known as "ectotrophic mycelia," and is how the fungus spreads along roots before penetrating into the root interior (Figure 5).

Figure 5. "Ectotrophic mycelia" P. Weirii on surface of infected root

To examine for mycelia, scrape away the soil from lateral roots adjacent to the base of the suspect tree and look for a grey-white to tawny to light purple fungal mycelia around the entire outer surface.

If you suspect laminated root rot, a final diagnosis can be made most easily from the characteristic, advanced decay in the roots and butts of infected trees (Figure 6).

Figure 6. Advanced Decay Caused by *P. weirii*

Advanced decay, most readily evident on windthrown trees with roots broken off near the ground, separates easily among the annual rings – thus the name “laminated” root rot. The wood is heavily pitted on both sides by pits about 0.5 millimeter wide and 1 millimeter long. Close examination of this decay with a 10x or stronger hand lens should reveal setal hyphae (Figure 7), a type of fungal structure appearing like tiny, reddish whiskers about 0.3 millimeters long. Setal hyphae indicate P. weirii.

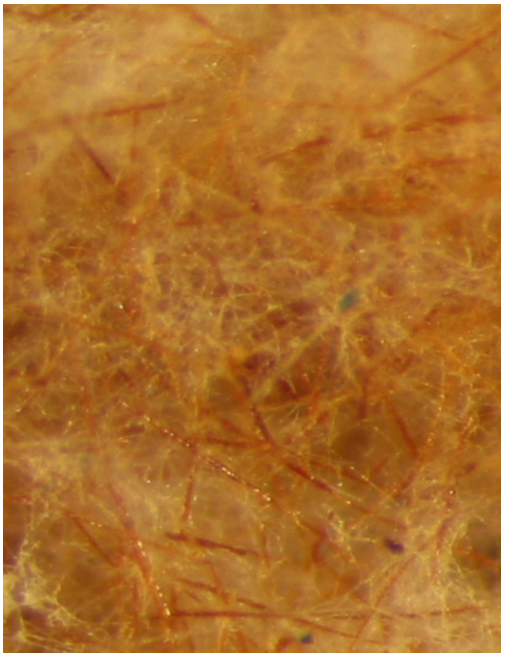

Figure 7. Setal hyphae of P. weirii (Photo by Brennan A. Ferguson, Ferguson Forest Pathology Consulting, Inc.)

Management

Root disease management should be site-specific and based on stand-management objectives, the root disease or disease complex present, estimates of root disease severity, stand structure and composition, and stand history. Management of root disease is not a “one-size-fits-all” proposition so the following should be viewed as guidelines.

Determine objectives: Formulate management objectives for the stand in question. A timber production objective requires very careful consideration of root disease; other objectives may not.

Estimate "root disease severity": An estimate of root disease severity (Table 1) provides a "snapshot" of current root disease impact and mortality rates, as well as the best estimate of future mortality and the trajectory of stand structure and composition. Root disease severity, and thus management, can vary throughout a stand.

Regeneration harvest/*stand establishment*: If root disease is severe and few disease-resistant species are available to select as leave-trees, and your objective is timber production, then the best option is to clearcut the stand and start over with seral species, such as larch and pines. Ensure quality-control during planting since "J-rooted" seedlings of any species are readily damaged by root disease.

Key Points:

- *Salvaging trees dead and dying due to root disease will capture the volume before it becomes unmerchantable, but due to the biology of the fungi that cause root disease, salvage <u>does</u> <u>not</u> reduce continued mortality or halt spread of root disease.*

- *Managing for disease-tolerant species is usually the most effective and cost-efficient means of managing root diseases.*

Precommercial stands: Many stands composed of disease-susceptible species have been established, either by planting or natural regeneration, in the presence of moderate to severe root disease. Such stands often show few symptoms of disease until 15-20 years later, or more in the case of laminated root rot, when roots of growing trees have contacted inoculum from the previous stand and damage from laminated root rot becomes apparent. In such instances, whether precommerical thinning has been done or not, the best option may be to destroy the current stand and start over with disease-tolerant species; a better yield will almost certainly result.

If a young stand has extensive root disease mortality but includes well-distributed, disease-tolerant species then delay thinning at least several years to allow the root disease time to "select" which trees will survive before you invest in thinning. If thinning is eventually done leave a higher-than-normal stocking of disease-tolerant trees in anticipation that more will die as the stand matures. In many instances, however, root disease will reduce stocking to where only "clumps" may need thinning.

Young stands with a "light" root disease severity rating can be thinned without delay, but emphasize selection of disease-tolerant species over maintaining uniform spacing.

Achieving root disease management objectives during precommercial thinning requires close administration of thinning crews. Without it a poor job of thinning can result, reducing a forester's options in the form of species composition for literally decades to come.

Key point: *Carefully planned and administered precommercial thinning, that favors and promotes root disease-tolerant species, will aid long-term disease management and protect your investment in site preparation, stand regeneration, and thinning.*

Commercial stands: Thinning is not recommended on ground impacted by laminated root rot if the most susceptible species, Douglas-fir and grand

fir, will **make up more than 30% of the leave-trees**. Many of the disease-susceptible trees will already be infected, even if not currently displaying crown symptoms, and often die within a few years of thinning.

A landowner may be sorely tempted to thin a root-diseased stand, leaving the best-looking Douglas-fir and grand fir, with the expectation these trees will experience "increased vigor" and thus resist root disease. The evidence is not clear at this time whether thinning accelerates damage in such a situation, but it is clear that ***mortality rates will not decrease in disease-susceptible species***.

> **Key point:** *Laminated root rot can infect and kill susceptible species of any age and size, regardless of perceived or actual vigor.*

Management of stands impacted by laminated root rot should emphasize promotion and maintenance of seral species. Silvicultural approaches that achieve this objective are recommended even for stands with a light root disease severity rating. Managing for disease-susceptible species, and harvesting the disease tolerant species, will result in ever-increasing amounts of disease inoculum and only serve to worsen root disease severity and reduce management options for the next rotation.

> **Key point:** *Long-term root disease management should take a "**do no harm**" approach by maintaining and promoting mature seral species and their natural regeneration, planting carefully with disease-tolerant species suited to the site, and avoiding actions that will increase inoculum levels.*

"Buffer removal" is one tool suggested for management of laminated root rot when disease center boundaries are discrete and final harvest is more than 10 years off. The concept behind buffer removal is to eliminate the live-root pathways among susceptible species believed necessary for the fungus to expand into non-infected portions of a stand. Various approaches have been described, ranging from removal of all trees for approximately 50-65 feet around infection centers, to removal of only the disease-susceptible species. Either way, all symptomatic trees from within the center should also be removed. If all trees have been removed from the infection center and buffer, and if the area is large enough, consideration can be given to planting with disease-tolerant species in order to utilize the site and prevent occupation by disease-susceptible conifers or brush.

> **Key point:** *The biggest problem with "buffer removal" for root disease management in northern Idaho forests is that few disease centers are well-delineated or well-separated from other root disease centers. In addition, more than one root disease organism often occupies a given site. Successful application of this treatment would probably meet with little success in northern Idaho forests.*

Inoculum removal: Using heavy machinery to remove stumps and large roots from the ground in root-diseased stands can reduce short-term damage in the subsequent stand due to reduction in inoculum, but long-term results are mixed. Against laminated root rot it has been practiced mainly on highly-productive, Pacific Coast Douglas-fir sites. Inoculum removal requires ***very careful*** consideration based on slope, soil moisture and type, and site productivity. While it is not considered economically practical in

commercial forests of Idaho, private landowners with small parcels of land impacted by root disease might consider this option under the right circumstances.

Fertilization: At this time there is no evidence that fertilization reduces the incidence or severity of laminated root rot.

Table 1. Root disease severity categories.

Root Disease Severity	Range of Conditions
Light	Includes stands with no evidence of root disease, stands with no mortality but numerous trees displaying symptoms, and stands with *up to 20% canopy reduction due to root disease mortality*.
Moderate	Includes stands with *20-75% canopy reduction due to root disease mortality*. At the lower end of this range there will also be many trees with root disease symptoms, while at the upper end much of the remaining overstory canopy consists of disease-tolerant species. Moderate severity stands are changing quickly; mortality rates are high.
Severe	Includes stands with *at least 75% canopy reduction due to root disease mortality*. These stands are usually composed of only the most susceptible species. At the lower end of this range only a few susceptible overstory trees remain although there may be densely stocked, susceptible regeneration; at the upper end no susceptible species remain in the overstory. Mortality rates in this category will begin to slow because most susceptible species are already dead.

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